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GENERAL ENTOMOLOGY

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CONTENTS

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2. **Local Committee of Management of Wicken Fen.**
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3. **National Trust for Places of Historic Interest or Natural Beauty.**
   Mr. W. G. Sheldon, appointed 1922.
4. **New Forest Association.**
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5. **Royal Meteorological Society. Phenological Committee.**
   Dr. C. B. Williams, appointed 1937.

PROCEEDINGS OF THE
ROYAL ENTOMOLOGICAL SOCIETY
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SERIES A. GENERAL ENTOMOLOGY

VOLUME 18. 1943.

A METHOD OF COLLECTING AND STORING WITHOUT PRESSURE INSECTS AND GALLS ATTACHED TO LEAVES

By C. B. WILLIAMS, Sc.D.

(Rothamsted Experimental Station, Harpenden, Herts.)

SOME years ago I was making collections of Scale-insects, White-flies (ALEURODIDAE) and entomogenous fungi in the Tropics. In the case of the ALEURODIDAE the immature stages are attached to leaves and are often covered with elaborate and characteristic wax outgrowths which are destroyed if the usual method of collecting in paper envelopes is adopted. In the case of the entomogenous fungi, the host insects are frequently attached to leaves by the fungus hyphae and there may be very characteristic slender outgrowths of fungus from the insect in all directions.

It was therefore important to have some simple method of collecting which would protect these from pressure and enable the specimens to be stored safely. The following was devised and it has worked excellently for many hundreds of specimens.

Round flat pill, or ointment, boxes made of cardboard, of the type shown in fig. 1A, were obtained. These were of varying sizes but the most useful were 1·75 and 2 inches in diameter and approximately 0·65 and 0·8 inches in depth respectively; these are outside measurements.

If such boxes are examined they will be found to be made up from three separate parts; the lid (*a*); the base (*c*) and a cardboard ring (*b*), which is lightly gummed to the base (fig. 1B).

The first process is to remove this ring, in as undamaged a condition as possible, from the base by slipping a small thin-bladed knife between it and the sides of the base. With a little practice this can be done in a moment or two even in the field, but it is simpler to prepare a number of boxes at home before collecting starts. If a large number of boxes were required it would probably be possible to obtain them directly from the manufacturers without the rings fastened in.

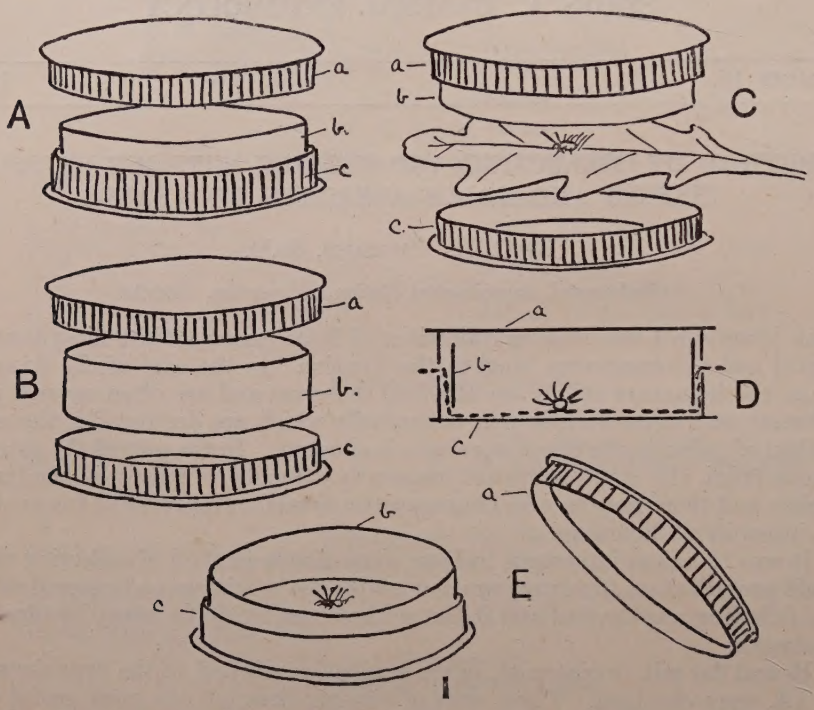
The three parts are then put together again and can be carried in the pocket or haversack without damage.

When the specimen required is found attached to a leaf, grass-blade, or thin twig in the field, the box is opened and arranged so that the central ring is in the lid and not in the base (fig. 1C). This is held above the specimen, and the base of the box below so that the specimen is near to the middle of the box.

Then the lid and base are pushed together with a slight turning movement to force the leaf into the base of the box and to jam it there with the ring (fig. 1D).

If the leaf is very tough or thick there may be a little difficulty, but in most cases there is none. Any leaf remaining round the outside of the box can be cut off.

If the lid is now carefully removed, with a slight turn, the ring will stay jammed to the base and the specimen will be well displayed in the middle of



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the box (fig. 1E). It may be necessary, as the leaf dries, to remove the ring and fix it down more firmly with a small amount of gum.

The data should be written on the bottom of the box rather than the top, as there is always a danger of the tops getting interchanged.

The boxes should be finally stored in a larger case with a liberal supply of naphthalene or other preservative.

On one occasion I obtained a small number of boxes of similar construction but with glass lids. These were of course very convenient indeed but considerably more expensive.

I have specimens which have been stored in this way over twenty years and they are as undamaged today as when they were first collected.

A SAFE METHOD OF MEASURING THE WINGS OF SET BUTTERFLIES

By C. B. Williams, Sc.D.

(*Rothamsted Experimental Station, Harpenden, Herts.*)

In the course of some work on variation in the Monarch Butterfly (*Danaus plexippus* L.), I had to measure the length of the fore-wing of several hundred specimens, chiefly set and stored in glass-covered drawers.

The first method adopted was to use a pair of dividers with a screw adjustment. This was first placed as near as possible to the wing, adjusted to agree with the length, and then transferred to a millimetre scale where the required figure was read off.

This necessitated the removal of the glass cover to the cases, and needed a steady hand if the chance of occasional damage to specimens was to be eliminated.

The following method was then devised to enable specimens to be measured without removing the glass covers of the cases.

Two identical glass scales (fig. B) are mounted about three-quarters of an inch apart, the upper one exactly above the lower. The double scale so produced is placed on the glass top of the case (fig. A) and, with the help of a low-power lens, it is adjusted until the scale is along the object to be measured, and one end of this, the ends of the lower scale and the upper scale, and the eye are all in a straight line. The scale is then kept fixed, and the eye moved along the scale till the other end of the line to be measured is in line with the eye and the same measurement on each of the two scales. With a little practice this point can easily be found as a very slight movement of the eye will put the two scales out of register at the required spot.

It will be obvious that the reason for the double scale is to eliminate the parallax errors from the measurements.

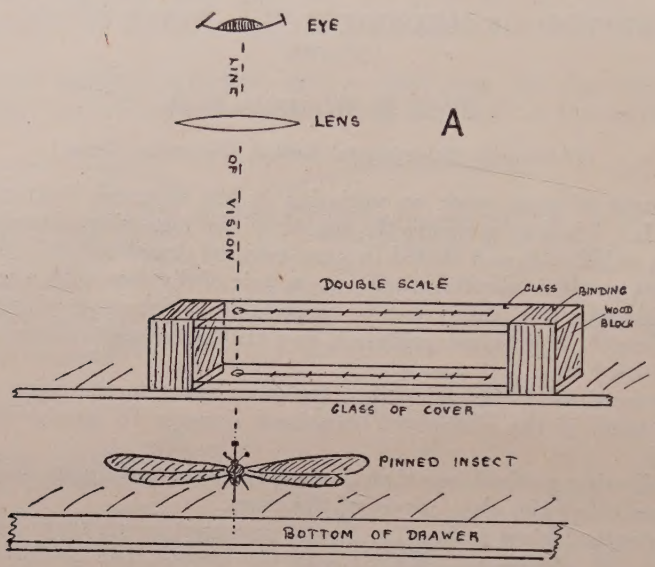
The scale that I have found most satisfactory for my purpose is one 70 mm. long (about 2·8 inches) and graduated every 2 mm. Readings can be made with this to about half a millimetre.

A dark scale is more useful for measuring pale insects, and a white scale for dark insects. To avoid the necessity of having two instruments, I have made my scales with a black and a white scale side by side. The black portion is made by photographic reduction on to a quarter-plate transparency, and the white scale is made by over-ruling a similar black scale with white photographic ink with a ruling pen. The white scale is not quite so fine as the black but is sufficiently good for the purpose required.

Two identical scales are photographed just over one inch apart on a single quarter plate, so that by means of a glass cutter the two upper and lower scales can be produced in one operation.

The operation of reading is made easier by using a low-power lens of the reading-glass type between the eye and the scale. I use one of about 7-inch focal length and find that it is most comfortable when the eye is about $6\frac{1}{2}$ inches and the lens about $4\frac{1}{2}$ inches above the glass top of the drawer.

The double scale is made up from the two glass scales cut from the quarter plate, by binding the ends to two identical wooden blocks with adhesive tape


EYE
LINE OF VISION
LENS
A
DOUBLE SCALE
GLASS
BINDING
WOOD BLOCK
GLASS OF COVER
PINNED INSECT
BOTTOM OF DRAWER

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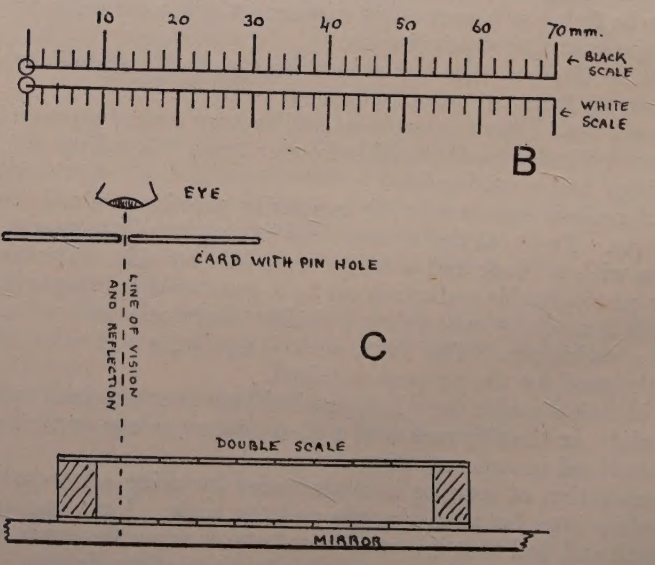

10
20
30
40
50
60
70mm.
← BLACK SCALE
← WHITE SCALE
B
EYE
CARD WITH PIN HOLE
LINE OF VISION AND REFLECTION
C
DOUBLE SCALE
MIRROR

2

or the adhesive lantern-slide binding material sold by Messrs. Kodak and possibly other manufacturers.

It is most important that the upper scale should be exactly above the lower. The best way to fix this appears to be as follows: attach the lower glass scale to the two end blocks, place the upper scale loosely on the blocks and put the whole on a mirror lying on the table (fig. C). Then inspect it from above by looking through a large pinhole in the sheet of white card (*e.g.* a postcard). Then adjust the upper scale until the image of the pinhole below the mirror, one end of the lower scale and the corresponding end of the upper scale are in exact line. Then partly fasten down this end of the upper scale. This is repeated with the other end of the two scales and the upper scale is finally fastened down. The whole process of making up the double scale should not take more than two or three minutes.

I shall be happy to assist in any way possible anyone wishing to make one of these measuring scales.

Book Notice.

Introduction to applied entomology. 2nd edition. By W. J. Baerg. 4to. Minneapolis, Minn. (Burgess Publishing Co.) 1942. pp. 146, 128 text illust.

This is the 2nd edition of a work published in 1937 especially for students at the University of Arkansas. It is intended to acquaint the student with the common insect pests and some of the more important Arachnids.

The arrangement of the work is systematic and within the limits of the volume only the most important species can be mentioned.

For each order of insects a brief introduction is given, followed by a description of the most important economic species. An account of the life-history follows and there is a description of the most successful control measures.

There is an illustration of most species dealt with in the work and all the illustrations are original.

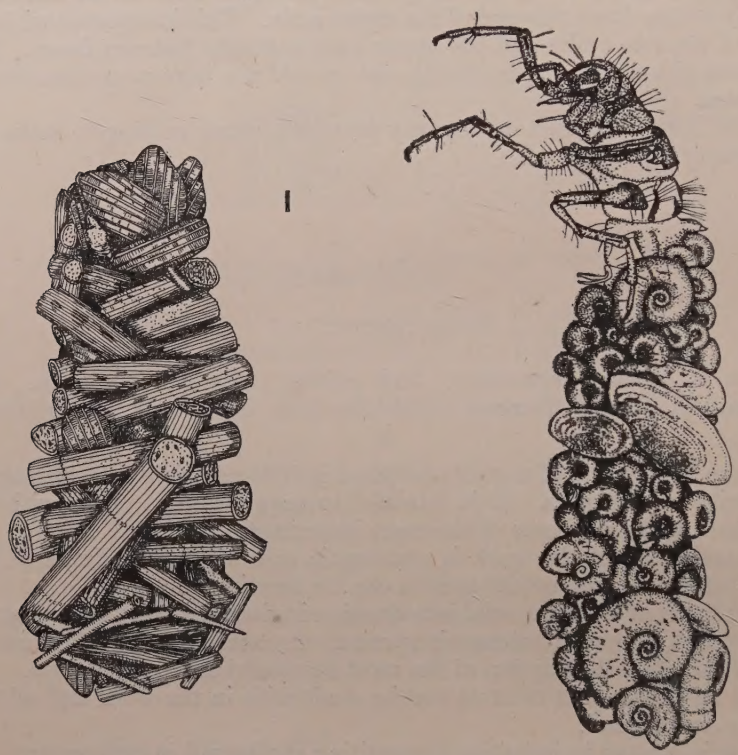
The book is printed in imitation typewriting and bound in stiff paper.

LARVAE OF THE BRITISH TRICHOPTERA. 8

By N. E. Hickin, Ph.D., F.R.E.S.

Limnophilus flavicornis L. (Limnophilidae).

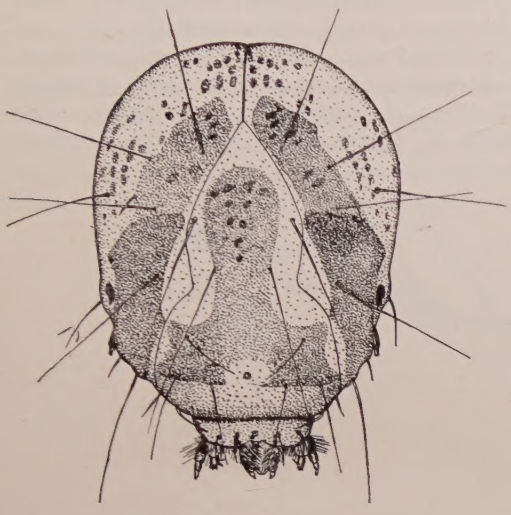
Larvae of this widely distributed species were found to be exceedingly numerous in a number of small cattle ponds in the Coleshill district of Warwickshire. In addition, numerous specimens were collected from a pool in Broadmoor



Figs. 1–2.—1, Case. 2, larva and case.

Wood, Rubery, Worcestershire. Some of the larvae were reared to the adult stage and the species determination confirmed. One of the cattle ponds referred to above had deteriorated into a rubbish dump and the only living vegetation present was algal, but even so the larvae were present in very large numbers. The other pools were characterised by having an extensive marginal and floating vegetation.

Case: cylindrical, made up of a variety of materials cemented together. The younger larvae had constructed their cases of the leaves of *Lemna* placed edgewise, older larvae had cases of the cut stalks of Potamogeton and reed, small sticks, dead leaves and other vegetable debris and snail shells. The material forming the case is usually arranged in criss-cross fashion, obliquely to the axis of the case (see fig. 1). Many of the larval cases from the pool in Broadmoor Wood obtained from submerged branches were constructed entirely of the shells of molluscs cemented together (see fig. 2). Several *Limnophilus*



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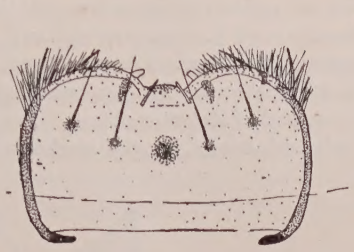

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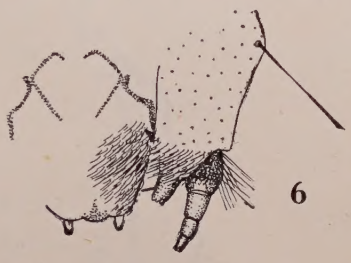

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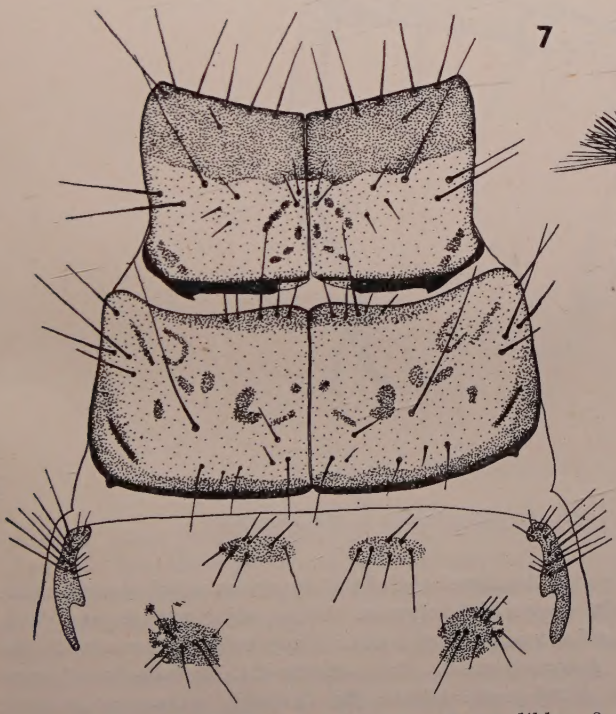

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FIGS. 3–7.—3, Head. 4, labrum. 5, mandible. 6, maxilla and labium. 7, thoracic nota.

species use mollusc shells as case-building material. Mosely gives photographs of cases of *L. rhombius* and *L. lunatus* as well as *L. flavicornis* in which mollusc shells have been used. Anterior end oblique. Length 26 mm., breadth 7 mm. *Larva*: eruciform, cylindrical, head orthocentrous. Pro- and mesonota sclerotised, metanotum with sclerotised patches. Posterior end of abdomen obtuse. Length 20 mm., breadth 5 mm. *Head* (fig. 3): elliptical, yellowish-brown, heavily marked with black. Clypeus at oral end almost completely

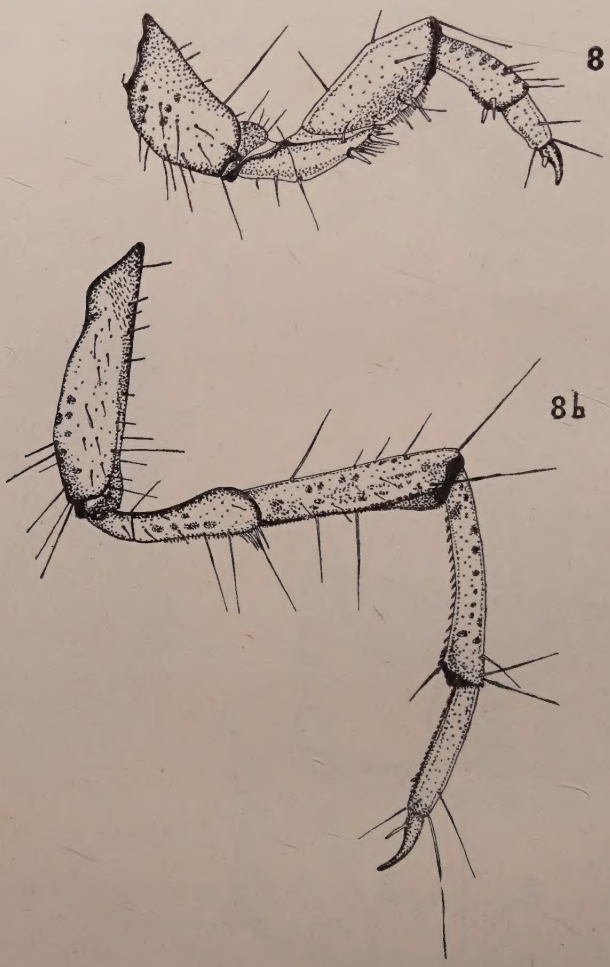

Fig. 8.—Legs: a. prothoracic; b. mesothoracic.

black, the dark area extending into the aboral end of the clypeus as a club-shaped mark. The latter does not extend to the margin of the clypeus. Genae, adjacent to clypeus, dark, making an inverted V, oral half of mark almost black. Many small dark marks on the genae lateral to the V mark. Antennae small. Gular sclerite (fig. 10) flask-shaped, completely separating the genae. *Mouth-parts*: labrum (fig. 4) deeply concave on anterior margin with small cushion-like protuberance at the centre. Small pear-shaped dark mark on each side of this protuberance. Heavily sclerotised lateral margins, and a small dark

mark in the centre of the transverse row of bristles. *Mandibles* (fig. 5): obtuse, 4-toothed, brush of fine hairs on inner edge. *Maxillae* (fig. 6): base of palp and mala sclerotised, chestnut-brown in colour. *Labium*: hairy. Two sets of bow-shaped sclerites are visible. Labial palps situated on dome-shaped protuberances. *Thorax* (fig. 7): prothorax sclerotised, strong bristles situated along anterior margin, anterior third almost black in colour, remainder dark chestnut-brown except posterior margin, which is heavily sclerotised and black in colour. Mesothoracic notum sclerotised, anterior margin greyish, posterior margin black. Transverse variable pattern of dark marks. Metathoracic notum with sclerotised

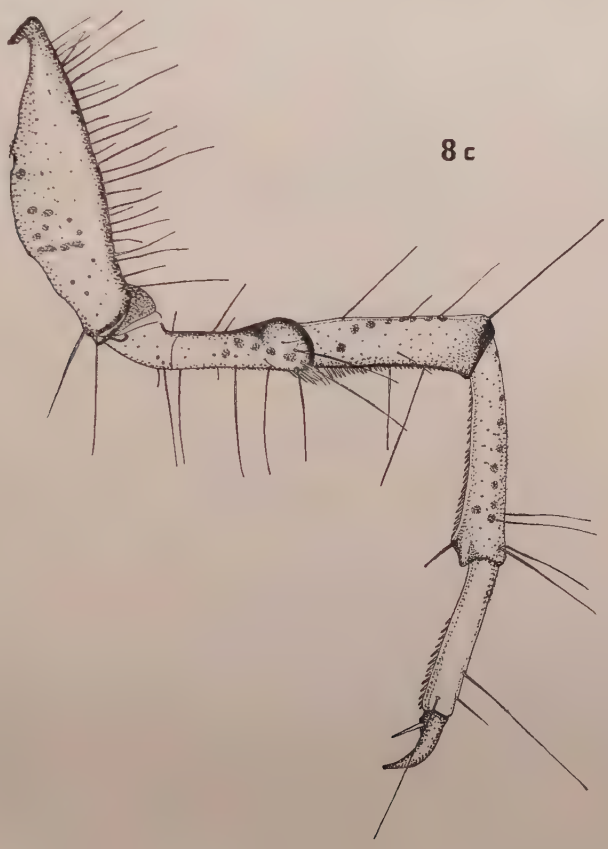

Fig. 8c.—Metathoracic leg.

patches. Large patches in the pleural region furnished with bristles on the anterior half. Two small sclerotised patches situated anteriorly and two posteriorly, the latter half-way between the former and the pleural plates. Prosternal horn present. *Legs* (fig. 8, a, b and c): prothoracic legs short, spines of unequal size at distal end of trochanter. Series of small spines along ventral edge of meso- and metathoracic tibial and tarsal segments. *Abdomen* dorsal and lateral protuberances on first abdominal segment. Numerous gills in groups of three present on segments 2–8. Anal sclerite (fig. 9) elliptical, anterior margin dark. Four large bristles on posterior margin with a small bristle situated in the centre. Each anal claw with two auxiliary claws at its base, one smaller than the other. Lateral line present in

abdominal segments 3 to 8 inclusive together with groups of from 4 to 7 small sclerotised pustules at the anterior end of the segment.

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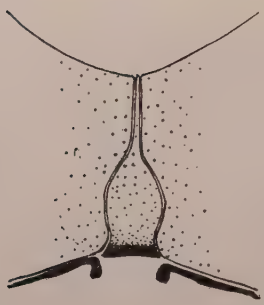

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FIGS. 9–10.—9, Anal sclerite. 10, gular sclerite.

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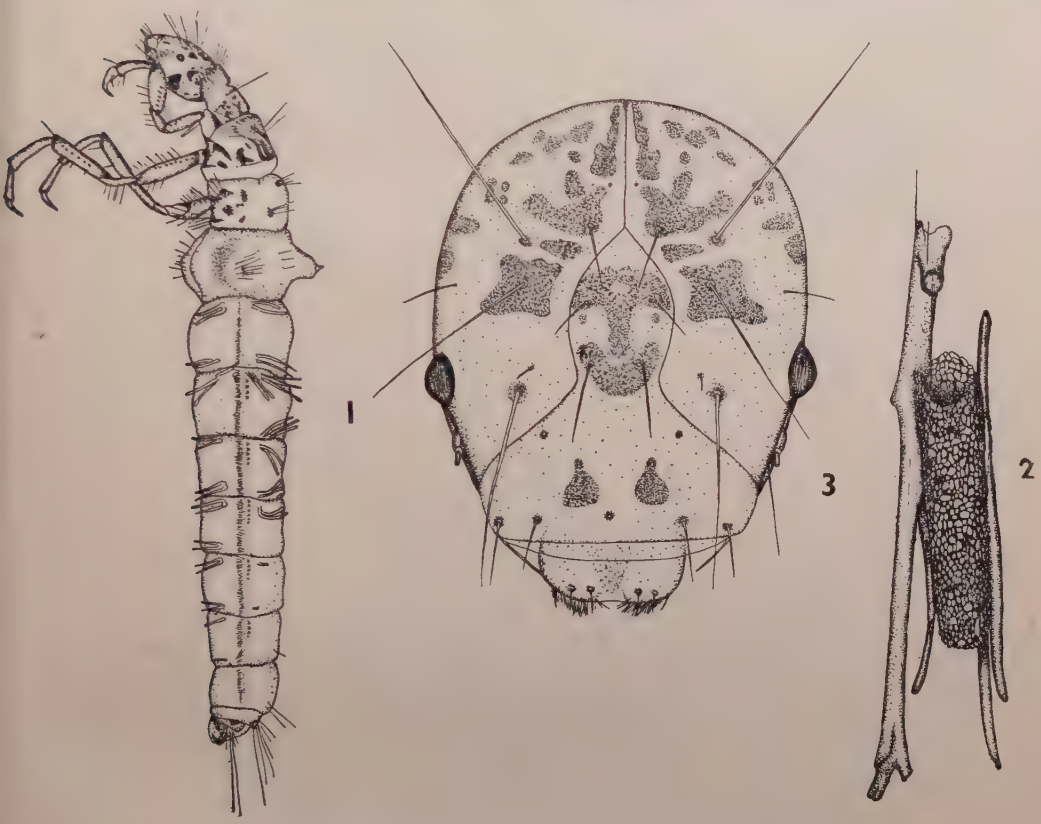
——, 1909, *Süsswasserfauna Deutschlands* **5, 6 :** 260.

LARVAE OF THE BRITISH TRICHOPTERA. 9

By N. E. Hickin, Ph.D., F.R.E.S.

Anabolia nervosa Curt. (Limnophilidae).

Two streams, one at Temple Balsall, Warwickshire, and the Dowles Brook, near Bewdley, Worcestershire, were found to be very thickly populated with larvae of *Anabolia nervosa*. Several were reared to the adult stage for the determination to be confirmed. Both streams are rapidly flowing, but larvae



Figs. 1–3.—1, Larva (lateral view). 2, case. 3, head.

were also collected from a stagnant flood pool on the river Rea at Cleobury Mortimer, Shropshire. The latter larvae appeared quite healthy although the head and thorax were covered with adherent mud, and festooned with green algae.

Case (fig. 2): conical, of sand grains cemented together. Anterior opening oblique. One or more sticks or twigs cemented longitudinally to conical sand-grain portion. Length 26 mm., breadth 6 mm. (sand-grain portion), the sticks may increase the over-all length to as much as 60 mm. Ulmer gives dimensions slightly in excess of these. It is probable that my specimens tend to be small. In the young larvae the case consists of small pieces

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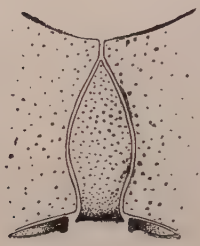

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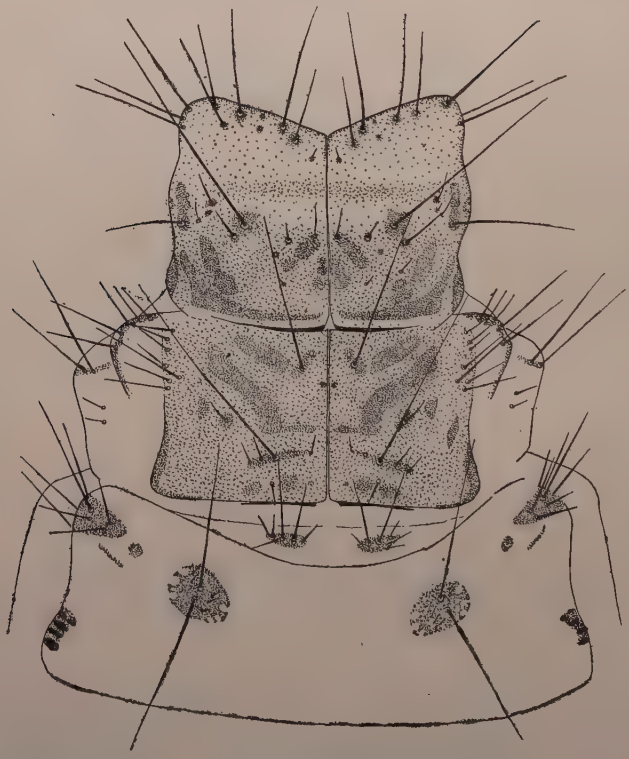

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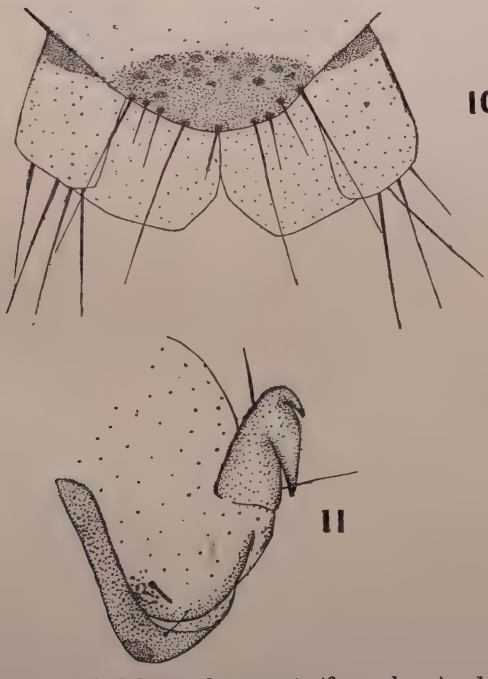
FIGS. 4–8.—4, Labrum. 5, mandible. 6, maxilla and labium. 7, gular sclerite. 8, thorax.

of cut stalk, stick and vegetable debris arranged longitudinally with a large stick cemented to the side. *Larva* (fig. 1): eruciform, cylindrical, head orthocentrous, pro- and mesonota sclerotised, metanotum with scattered sclerotised plates. Abdomen white, obtuse. Length 18 mm., breadth 4 mm. *Head* (fig. 3): elliptical, yellowish-brown with dark reddish-brown almost black markings. The extent of the marking is variable but the marking given in the figure is about average. At the aboral end of the clypeus is a T-shaped mark with a

FIG. 9.—Prothoracic leg.

yellow mark at the confluence of the strokes. At the base of the T is situated a bow-shaped mark. Between the two marks is a small dark discrete spot on each side. Two pear-shaped dark marks at oral end of clypeus. On the genae a number of irregularly shaped marks make up an inverted V. Chaetotaxy as in fig. 3. Antennae very small. Gular



FIGS. 10–11.—10, Terminal abdominal segments (from above). 11, abdominal claw (from below).

sclerite (fig. 7) not completely dividing genae. *Mouth-parts. Labrum* (fig. 4): partially sclerotised along outer margin and centre. Besides a series of spines (3 pairs along outer margin and 3 other pairs), a fringe of fine hairs occurs along anterior margin. Mandibles (fig. 5) acute, 4-toothed with two brushes of hairs along inner edge and two bristles at base of outer edge. Maxillae hairy (fig. 6), palp 4-segmented. Tip of mala palpiform. *Thorax* (fig. 8): prothorax sclerotised with longitudinal median suture, strong bristles along anterior margin. Pattern of dark marks in posterior half of prothorax with a medium row of bristles anterior to the latter. Prosternal horn present. Mesothoracic nota sclerotised with median longitudinal suture and about equal in size to prothorax. Unsclerotised pleural regions extend laterally. A pattern consisting of oblique dark marks situated in mesothoracic notum. The latter marks are variable in intensity but the figure shows average marking. Mesothorax with a few sclerotised patches, three pairs of which are furnished with bristles. It will probably be necessary to soften the sclerotised pro- and mesothoracic nota by boiling in caustic soda solution before the pattern can be observed. Prothoracic leg (fig. 9) with spines of unequal size on ventral edge of femur. *Abdomen*: first abdominal segment devoid of gills, median dorsal and lateral protuberances present, strong bristles present around base of median protuberance. Small sclerotised patch furnished with strong bristles on each side in pleural region. Lateral line present consisting of fine hairs, and in segments 3–7 a series of small pustules 5–7 in number, with sclerotised extremities dorsal to the lateral line and in the anterior half of the segments. Abdominal filiform gills present. Anal claws small, surmounted by a small auxiliary claw (fig. 11). A bow-shaped sclerite at base of claw. Extremity of ninth segment sclerotised on dorsal surface with a series of bristles of unequal length along posterior margin (fig. 10).

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Rousseau, E., 1921, *Larves et Nymphes Aquatiques des Insectes d'Europe* : 749, figs. 260, 263.

Ulmer, G., 1903, *Metamorph. Trichopt.* : 61, fig. G.

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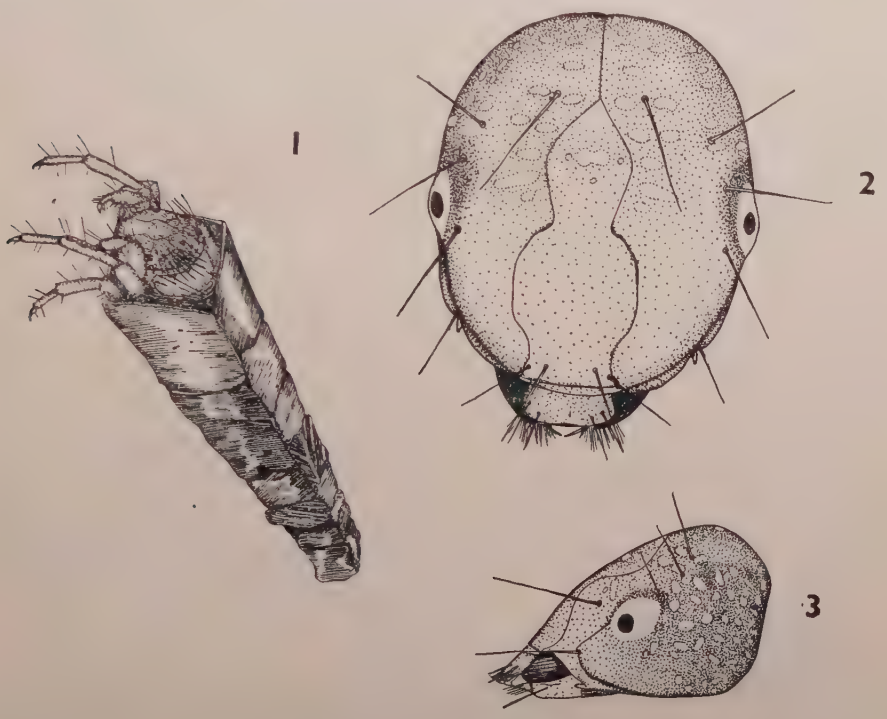
LARVAE OF THE BRITISH TRICHOPTERA. 10

By N. E. Hickin, Ph.D., F.R.E.S.

Lepidostoma hirtum F. (Sericostomatidae).

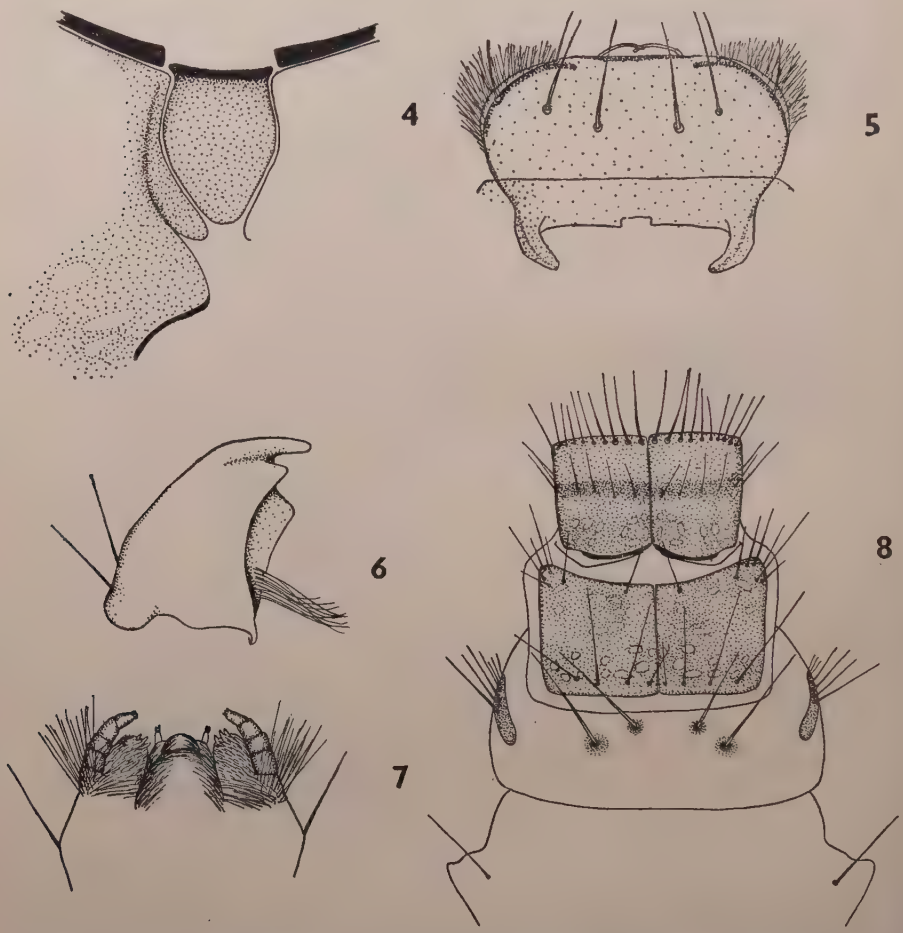
A large number of larvae were collected from a small stagnant flood pool at the side of the river Rea at Cleobury Mortimer, Shropshire. The larvae were clustered on submerged grass stems. Several were reared through to the adult stage for the species determination to be made.



Figs. 1–3.—1, Larva in case. 2, head (from the front). 3, head (from the side).

Larva: eruciform, cylindrical, head and thoracic sclerites dark golden-brown, abdomen white. Length 11 mm., width 2 mm. *Case* (fig. 1): of vegetable debris. Square cross-section tapering distally. The vegetable debris of which the case is composed is hardened, apparently by the secretion by means of which it is cemented together. Young larvae construct cases of sand grains. Length 17 mm., width 2·5 mm. *Head*: almost spherical, dark golden-brown in colour, finely sculptured. Eyes situated in white patches. Oral end of clypeus narrow, not extending to the full width of the head. Pattern of light-coloured patches as shown in figs. 2 and 3, within the clypeus at the aboral end and on the genae. Antennae very small. Aboral end of gular sclerite obtuse. Wing-like appendages of genae adjacent to gular sutures (fig. 4). *Mouth-parts*. *Labrum* (fig. 5): centre of anterior margin sclerotised, transverse, not concave, sclerotised lateral margin curves inwards. Transverse row of robust bristles across centre of labrum. *Mandible* (fig. 6): three-toothed with tuft of fine hairs at the base on the inside edge. *Maxilla* (fig. 7): palp four-segmented, hairy at base. Mala obtuse, hairy with a few papillae at the distal extremity. *Labium*: bulbous

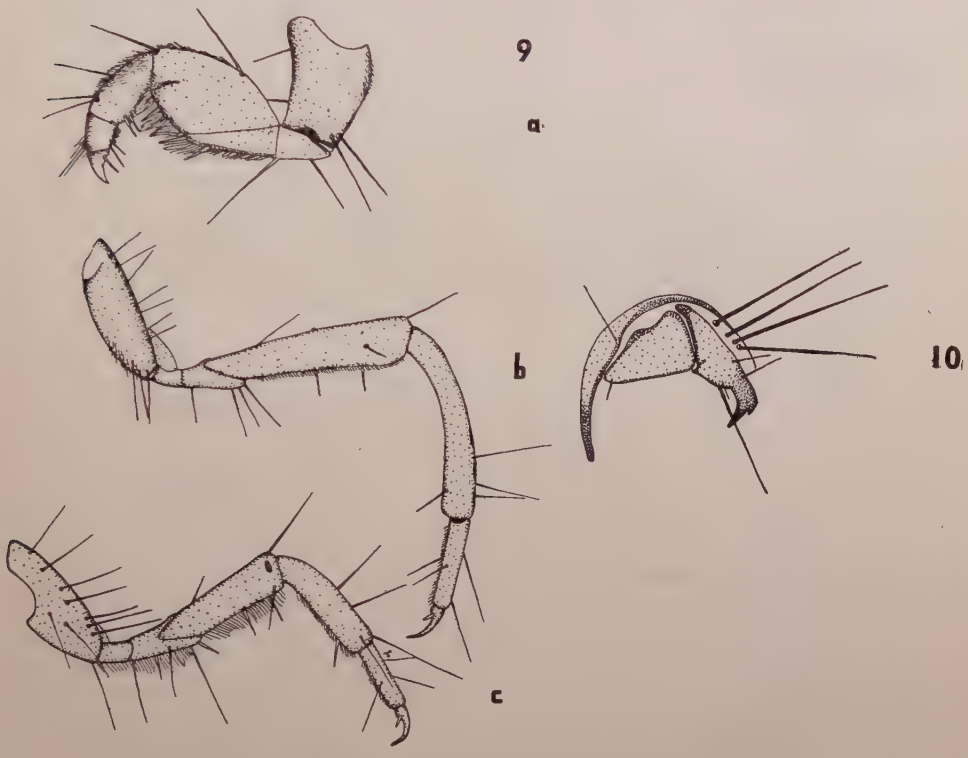
covered with small hairs. Labial palps situated on bulbous bases. *Thorax* (fig. 8): prosternal horn very small. Prothorax sclerotised with longitudinal suture. Dark golden-brown with slightly darker transverse band. Row of bristles along anterior margin with a second row transversely approximately in middle of notum. Pattern of light marks in posterior half of



Figs. 4–8.—4, Gular sclerite. 5, labrum. 6, mandible. 7, maxilla and labium. 8, thoracic nota and first abdominal segment.

notum. Posterior margin black. Mesothoracic notum sclerotised, rectangular, shield-like, with longitudinal suture. Dark golden-brown, wider than prothorax. Pattern of light marks as shown in figure. Several bristles at lateral position near anterior margin, and a transverse row of strong bristles near posterior margin. Metathorax wider than mesothorax, unsclerotised except for six small patches. Two pairs of the sclerites are very small and situated on the dorsal surface of the metathorax. These sclerites occur at the base of bristles. The anterior pair are closer together than the posterior pair. The remaining pair are larger, lunate and situated laterally. A few bristles are situated at the anterior end of these latter sclerites. *Legs* (fig. 9, a, b and c): prothoracic legs short and thick, mesothoracic legs slightly longer than the metathoracic. Chaetotaxy as in the figures.

Abdomen: lateral protuberances on first abdominal segment pointed and directed anteriorly. Median dorsal protuberance absent. Lateral line indistinct but groups of small chestnut-brown pustules present near lateral line in anterior half of segments three to eight. Gills present, two single gills on dorsal surface of segment 2, and two on ventral surface arising from near posterior margin. In segments 3 to 6, there are four single gills arising from near



FIGS. 9–10.—9, Leg: a. prothoracic; b. mesothoracic; c. metathoracic.
10, anal claw (from the side).

anterior margin, two dorsal, two ventral, and four single gills arising from near posterior margin, two dorsal and two ventral. In segment 7 there are four single gills, all arising from near posterior margin, two dorsal and two ventral. Each anal claw (fig. 10) with auxiliary claw. Sclerite supporting claw triangular. Four long black bristles.

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TWO RARE CUMBERLAND BUTTERFLIES

By E. B. Ford, M.A., B.Sc.

The two specimens described below were exhibited at the Society's meeting on 3rd February, 1943. Both are in my own collection.

1. A specimen of *Leptidea sinapis* L. captured in Cumberland in 1877. In this county the species has long been extinct, and indeed the records of its occurrence are very old and have appeared somewhat doubtful, especially as no Cumberland specimens were known to have been preserved. Moreover, this county would represent the northern limit of the species in Great Britain and, except for its existence in southern Westmorland up to the early part of the present century, the district is far removed from its present range. The example shown was obtained in "Suttle House Wood," but the name of the captor is not recorded. Suttle House is two miles from Carlisle on the Wigton road, and it is understood that a wood formerly existed in the adjacent fields to the west. All trace of this has long disappeared except for a fringe of trees beside the hedge, said to be a remnant of it. The specimen is a male, discoloured, and badly set in the old-fashioned style on an ordinary pin.

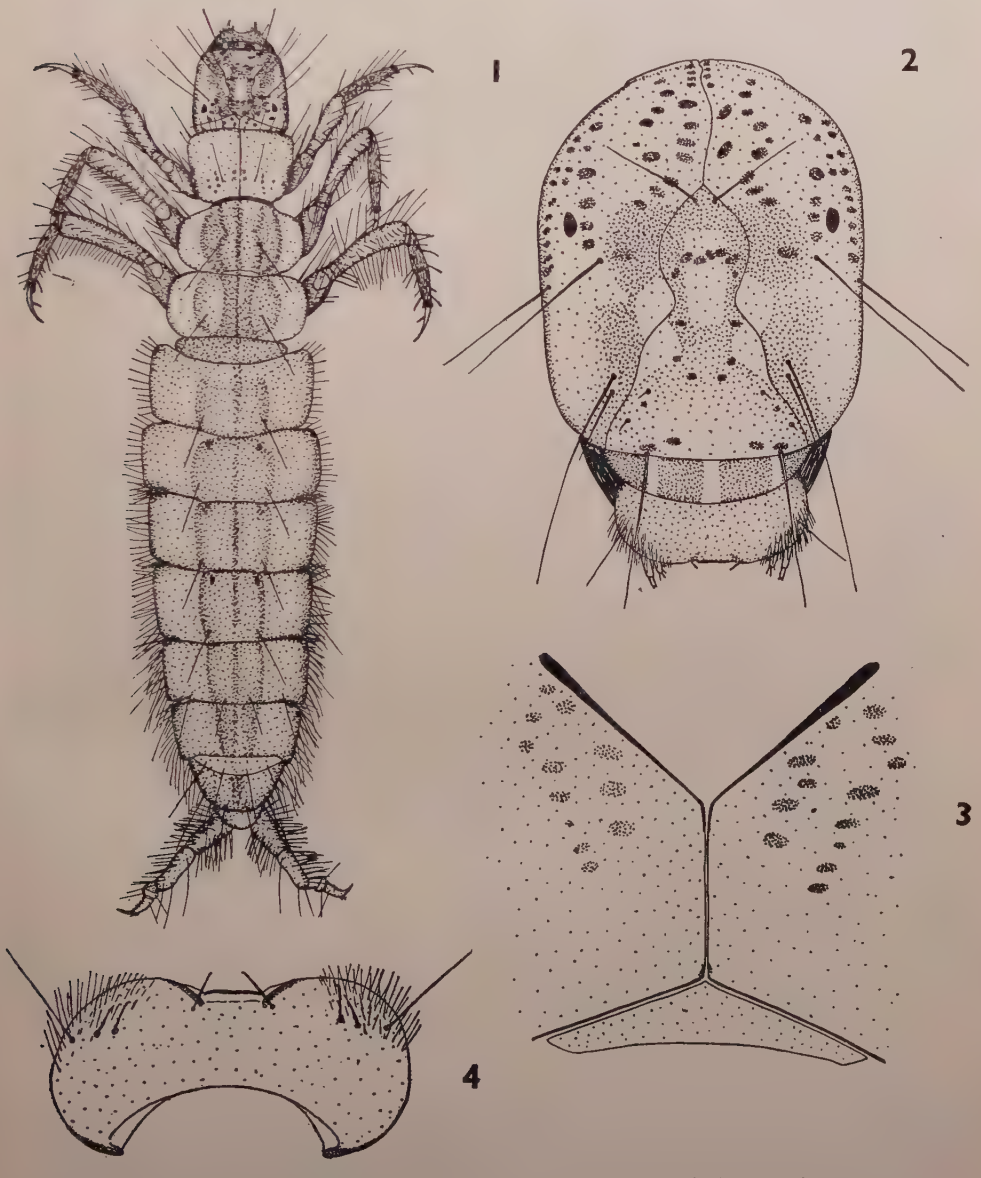
2. A specimen of *Erebia aethiops* Esper, captured at Keswick in 1899 by Mr. Tylecote. This is perhaps the only Cumberland specimen of *E. aethiops* extant. The species occurs, though rarely, in south Dumfries. It formerly existed in Northumberland, Durham, and north Lancashire, and persists in one locality in south Westmorland. This is now its only known English station. When it still occurred in the northern counties of England, it is supposed that its range surrounded but did not include Cumberland. The few Cumberland records are old, vague, and very dubious, while no specimens exist to substantiate them. In fact, the county seems only to have been mentioned in connection with the species because of the inherent probability that it should occur there. The specimen exhibited is a male in good condition, unusually dull in colour and poorly marked. Possibly it represents a survival of a former Cumberland colony, as Keswick is far from its known localities, and the species is a feeble flier and does not appear to be migratory.

LARVAE OF THE BRITISH TRICHOPTERA. 11

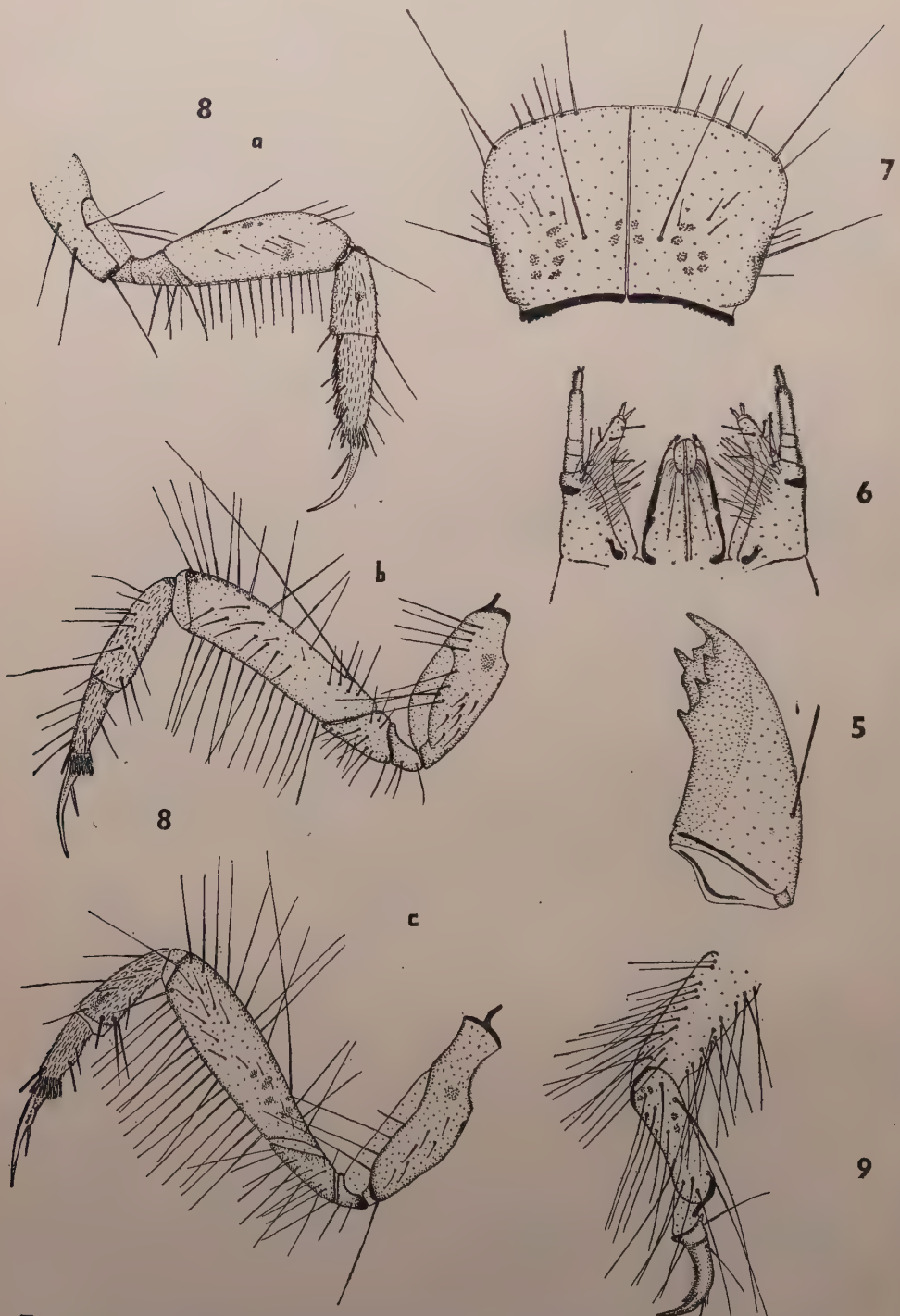
By N. E. Hickin, Ph.D., F.R.E.S.

Holocentropus dubius Ramb. (Polycentropidae).

Larvae of this species were collected from a pool at Barnslands, Cleobury Mortimer, Shropshire. The larvae had constructed silken nets and retreats on the underside of the floating leaves and on the stems of *Potamogeton natans*. This pool has a margin of trees but has very little vegetation apart from the *Potamogeton* already referred to.



Figs. 1–4.—1, Larva (dorsal view). 2, head. 3, gular sclerite. 4, labrum.



FIGS. 5–9.—5, Mandible. 6, maxilla and labium. 7, prothorax. 8, legs: a. prothoracic; b. mesothoracic; c. metathoracic. 9, anal claw.

Larva (fig. 1): campodeiform, head procentrous, only prothorax sclerotised. Length 12–14 mm., width 2·0–2·5 mm., widest at about the third abdominal segment. Abdomen flattened dorso-ventrally, tapering distally with deep intersegmentation. *Head* (fig. 2): light golden-brown, elliptical with genae parallel. Prominent transverse ridge for insertion of neck muscles. Irregular and variable pattern of dark marks at aboral end of head. Clypeus greyish-brown with a medium light golden-brown rectangular mark at the aboral end and a pair of triangular light marks fusing with two light marks on the genae. Except for a patch near the aboral end of the clypeus, the region of the genae adjacent to the clypeus is greyish-brown. The anteclypeus is large and well defined. It is divided into four dark areas by three longitudinal light marks. Antennae very small. *Mouth-parts. Labrum* (fig. 4) with concave posterior margin and hemispherical lateral margins. Central region of anterior margin concave with flat cushion-like protuberance. *Mandibles* (fig. 5): acute, inner face concave. Thin black line almost encircling base. *Maxillae* (fig. 6): maxillary palp of four segments, third segment long, a small sclerotised patch at base of palp and one on each side adjacent to insertion of base of labium into mentum. Tip of maxillary palp slightly darker in colour. Mala extends approximately to the centre of the third (long) segment of the maxillary palp. Four spines on the mala are directed inwards and one small one outwards. *Labium*: conical spinneret well defined and terminates in an oval organ situated between the small labial palps. *Gular sclerite* (fig. 3): narrow, transverse, does not divide the genae. *Thorax*: prothorax (fig. 7) sclerotised with longitudinal median suture. Posterior margin heavily sclerotised and black in colour. Bristles situated on anterior margin but not in central region near the suture. One long bristle on each side in pleural region. A few dark marks in posterior half of prothorax with bristles of unequal length extending transversely, a dark patch on each side. Meso- and metathorax elliptical, lighter at the sides, metathorax slightly wider than mesothorax. Prosternal horn absent. *Legs* (fig. 8, a, b and c): in each case tibial and tarsal segments covered with fine hairs. Claw long, with base encircled by group of branched bristles. Claw spine on mesothoracic legs approximately half-way along claw. In each case ventral edge of femur with equally spaced bristles. *Abdomen*: first segment narrow and thin, segments 2 to 8 darker in the centre on the dorsal surface, and with fairly long hairs in pleural region. Posterior margin of seventh segment with fold of skin partly overlapping segment 8. Anal claw (fig. 9) long, with fringe of spinules on concave edge and three spines (one large and two small) on the dorsal convex edge. Claw strongly curved. The two long supporting segments each covered with many long black hairs.

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THE EJECTION OF FRASS BY LARVAE OF *CALANDRA* (COL., CURCULIONIDAE) UNDER THE INFLUENCE OF CO_2

By O. W. Richards and T. A. Oxley.

The granary weevils, *C. granaria* (L.) and *C. oryzae* (L.), lay their eggs in grain and the whole of the larval and pupal stages are spent in the same grain. Apart from the minute hole in which the egg was laid, the grain normally remains intact until the young adult bores its way out. It is observed that when *Calandra* is bred in dense cultures in a jam jar the interstices of the grain in the bottom half of the culture become full of white powdery frass which is not produced by the adults. Usually a few fourth-stage larvae, having apparently come out of the grain, are found embedded in the frass. It was discovered that if some infested grain is divided into two lots, one of which is kept in a shallow open culture while the other is kept in a corked flask, very little frass is produced in the first lot whereas a great deal may be produced in the second, in a 24-hour period. This frass appears in a number of separate piles associated with particular grains.

10 g. of grain infested by *C. granaria* was put in a petri dish with a glass lid sealed with vaseline and kept at 21° C. After 24 hours, 4 piles of frass were visible and after 48 hours, 6 piles. 10 g. of the same grain kept unsealed at 21° C. produced no visible frass in the same period. The grains adjacent to the piles were dissected and in each case one was found to contain a large fourth-stage (last instar) larva. Further dissections suggested that early fourth-stage and younger larvae do not eject frass. The hole through which the frass is ejected is very small, hardly visible. The frass is the normal product of larval digestion, but when ventilation is good it is allowed to accumulate round the larva in the grain.

A lot of infested grain (*C. granaria*) was sampled and found to contain 14 eggs, 5 first-stage, 7 second-stage, 4 third-stage and 10 fourth-stage larvae in 100 grains. The grain was thoroughly sieved and divided into three lots of 80 g. Lot A was put in a litre conical flask with a muslin top; lot B was put in a similar flask with a rubber bung. Lot C was put in a flask connected with a closed circulating system of 8-l. capacity, so that although CO_2 would accumulate it would do so very slowly. The flasks were incubated at 25° C. Each morning about 200 c.c. of the air in C were drawn off to estimate the CO_2 concentration in a Haldane apparatus. This method of sampling is not very accurate owing to leakages during the sampling process but it gives a useful picture of the rise in CO_2 concentration.

Over an 8-day period, no frass was visible in A, and sieving at the end showed that only 5 mg. had been produced. In B, no frass was seen after one day, but 14 piles were visible after 2 days and 18 after 3 days. After this the visible frass increased very little, probably because the CO_2 concentration was too high. Sieving after 8 days showed that 154 mg. of frass had been produced.

The data for C are given below :—

Day . . .	1	2	3	4	5	6	7	8
CO_2 % . .	1·5	2·7	3·9	5·0	4·3	3·8	6·2	8·6
Piles of frass .	0	0	0	0	1	1	1	3

When C was sieved on the eighth day, 236 mg. of frass were obtained. The irregularities in the CO_2 concentrations on the fifth and sixth days were due to leakages during sampling.

Four lots of 50 g. of infested grain (*C. granaria*) containing 27 fourth-stage larvae per 100 grains were sieved and put into conical flasks. Lot A was corked, B was attached to the circulating apparatus, and C and D were controls (flask closed with muslin). After 3 days at 25° C., the quantities of frass produced were as follows :—A 464 mg., B 15 mg., C 24 mg. and D 39 mg. CO_2 was now added to the air in the circulator, giving a concentration of 16·3% and B was reconnected to it. C was corked and D was kept as a control. After 1 day at 25° C. the cultures were sieved and the following weights of frass were obtained :—B 54 mg., C 221 mg., D 4 mg.

In a final experiment, 10 lots of 30 g. of infested grain (*C. granaria*) were kept in 2-lb. jam jars with muslin tops. Initially, about 27% of the grains contained fourth-stage larvae. The results of the experiment are given in Table 1. In the columns of " treatment ", C means that the grain was in a litre flask attached to the circulating system into which CO_2 of the concentration indicated had been introduced. Corked means that the grain was in a litre flask closed with a rubber bung. The controls were left in the jam jars. The cultures were sieved every 24 hours.

TABLE 1.

24-hour period no.	1		2		3		4	
	Treatment	Mg. of frass produced	Treatment	Mg. of frass produced	Treatment	Mg. of frass produced	Treatment	Mg. of frass produced
Lot A	C. 10·7%	165	—	—	—	—	—	—
B	Corked	76	—	—	—	—	—	—
C	Control	26	C. 7·1%	117	—	—	—	—
D	,,	15	Corked	76	—	—	—	—
E	,,	22	Control	14	C. 6·4% [1]	79	—	—
F	,,	15	,,	14	Corked	22 [2]	—	—
G	,,	21	,,	18	Control	8	C. 5·5% [3]	80
H	,,	25	,,	18	,,	11	Corked	81
I	,,	29	,,	42	,,	14	Control	27
J	,,	44	,,	32	,,	13	,,	30

[1] Initial concentration 6·4%. After 24 hours 7·0%.
[2] Some frass spilt.
[3] Initial concentration 5·5%. After 24 hours 6·0%.

The following factors have or may have an influence on the weight of frass produced :—(1) The number of larvae in different samples of the same lot of grain will vary within errors of random sampling. (2) It seems that larvae are specially sensitive during the central part of the duration of the fourth stage. The number of sensitive larvae may not only vary in different samples but may vary with time if the grain is kept for long at 25° C. (3) It is evident that a concentration somewhere near 10% produces the maximum effect. It is known that very high concentrations (>20%) merely narcotize the larvae, while they are not much affected by concentrations below 5%. (4) It is possible that a

gradually rising concentration (as in a corked flask) is more effective than sudden exposure to a moderate concentration. (5) It is possible that water or other metabolic products of the larvae have some influence, though probably not very much, on frass-production. (6) Oxygen-deficiency is another factor which may play some part.

If these sources of variation in the experimental results are allowed for, it seems clear that the accumulation of CO_2 to some level between 5 and 15% is the main cause of the ejection of frass by larvae of *Calandra granaria*. A sample of air drawn from the bottom of a jam-jar culture showed that the CO_2 concentration in the bottom half must reach at least the 5% level. A few experiments in which grain infested by *C. oryzae* was corked up showed that the process of frass ejection is essentially similar in that species also.

Summary.

1. Larvae of *Calandra* under good cultural conditions allow their frass to accumulate around them inside the grain in which they are feeding.

2. If CO_2 accumulates in a culture, the fourth-stage larvae make a small hole in the grain and eject much of the frass.

3. This result can be obtained by corking up infested grain, which produces its own CO_2, or by placing the grain in a suitable concentration of CO_2 artificially prepared. The most effective concentrations seem to lie between 5 and 15%.

Acknowledgements.

This work is part of a collaborative programme between the Department of Entomology of the Imperial College of Science and Technology and the Pest Infestation Laboratory of the Department of Scientific and Industrial Research and is published by permission of the Department.

Mr. J. D. Jones kindly helped with the work of measuring CO_2 concentrations.

BEAK-MARKED BUTTERFLIES

By Professor G. D. Hale Carpenter, M.B.E., D.M., F.R.E.S.

With 1 Plate.

Many specimens of butterflies bearing the Λ-shaped impressions of birds' beaks have now been amassed at Oxford, and a report on the results of the examination of about the first thousand has been published [1]; the work still continues. Two specimens bearing a beak-mark which appears to be the work of the same species of bird are worth illustrating. Fig. A, pl. 1, represents a male of *Danaus sita sita* Kollar, with locality data " Ta-tong-kiao ". It came from the Oberthür collection, and was captured by a native collector. The locality cannot be identified, but Mr. N. D. Riley kindly informs me that, judging from other specimens with the same data, it appears to be in Sze-Chuan. The left hind-wing bears an extremely clear beak-mark (A).

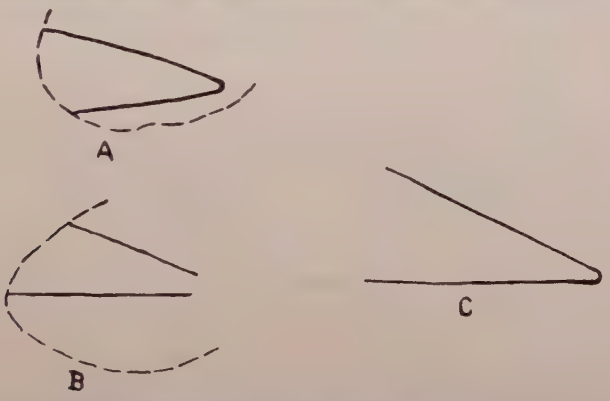


Fig. 1.—Beak-mark patterns. A, on *Danaus sita* Kollar; B, on *Euploea diocletianus* ♀; C, of the Greater Racket-tailed Drongo *Dissemurus paradiseus grandis* Gould.

The lower specimen (fig. B, pl. 1) is a male of *Euploea diocletianus* F., of the form which Tytler named *talboti*: this name is a synonym of *despoliata* Fruh. (*teste* N. D. Riley). The butterfly is one of many which Sir Murdoch McLeod, Bart., generously presented to Oxford some years ago: it was captured in Assam by C. B. Antram, July, 1920. It bears a beak-mark on the left fore-wing: the apex of the beak has not marked the sex brand (B). A number of irregular scratches on the disc of the opposite wing suggest that the struggles of the insect rubbed the wing against the beak. This form of *E. diocletianus*, according to information kindly supplied by Mr. Riley, is confined, so far as the national collections show, to Assam and the extreme north of Burma: *D. s. sita* extends from Sikkim to China and its range completely overlaps that of the *Euploea*. Seeking a bird with similar range, and a beak that could have made such an imprint I found that the Greater Racket-tailed Drongo *Dissemurus paradiseus grandis* Gould tallies very well. An imprint from its beak (C) corresponds closely in proportions and apical angle with the beak-marks on the two butterflies. It breeds along the Himalayas from Kumaon to eastern Assam and through to Yunnan from the plains up to 3000 and occasionally 4000 feet: it is an arboreal, forest, species inhabiting by preference the densest

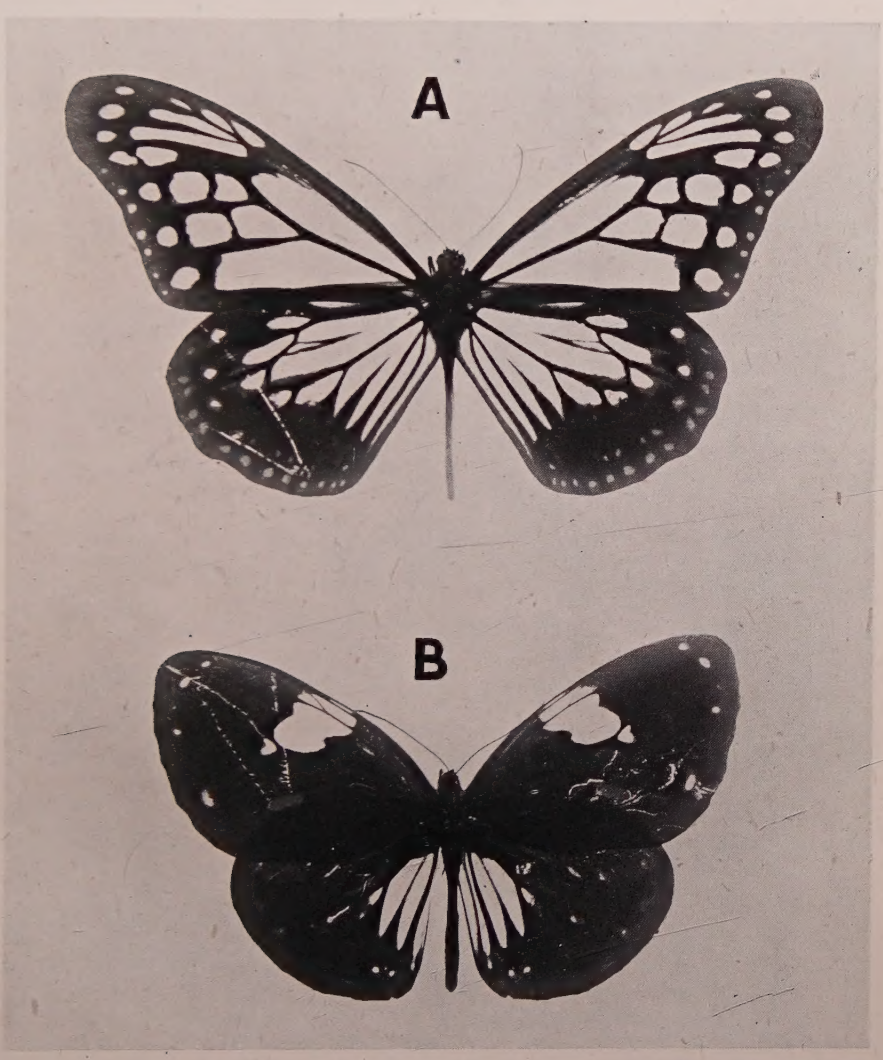
[1] Carpenter, G. D. Hale, 1941, *Proc. zool. Soc. Lond.* (A) **111**: 223–230.

and dampest of the Indian forests, but is also found in gardens.[2] The fact that both these butterflies, typically aposematic and models for mimicry, had escaped unharmed from attack by an insectivorous bird, has great significance.

Explanation of Plate 1.

A. *Danaus sita sita* Kollar ♂, showing beak-mark on left hind-wing.
B. *Euploea diocletianus* ♂, showing beak-mark on left fore-wing.

[2] Whistler, *Popular handbook of Indian birds.*



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G. D. Hale Carpenter. **Similar Beak-marks from different localities.**

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